ELECTRONIC TUNING WITH SEMICONDUCTOR DIODES

Presently under investigation within this Department are elctronic tuning systems using voltage-sensitive semiconductor diodes. Briefly, the potential barrier at the p-n junction of the diode is analogous to the dielectric film of a capacitor. The thickness of the junction can be controlled by varying the bias voltage across the diode. In effect, therefore, capacitive tuning is accomplished electronically through voltage control. Laboratory investigations of these devices are underway and have been directed toward further characterizing the capacitance-voltage relationship, Q, frequency range, and temperature stability of presently available diodes and devising the necessary control and compensating circuitry for a military quaility tuning system.

a. Tests made at several frequencies over a range of 5-100 mc show capacitance to vary inversely as the square root of voltage for the type of diodes used. Therefore, the capacitance and frequency change is very rapid at low voltage. The Q decreased with increasing frequency under constant bias voltage . As an example, the Q drops from a value of 35 at 38 mc to 20 at 80 mc with a 20 v dc bias. The capacitance range of the items sampled was approximately 4.5:1.

b. Non-linear solid state devices and non-linear voltage control net-works were investigated in order to obtain a Straight Line Frequency characteristic. Promising results were obtained using a voltage divider consisting of a two-ganged potentiometer with a resistance ratio of approximately 3:1. The maximum frequency deviation from a straight line over a frequency range of 9-19 mc was approximately 500 kc. The voltage versus rotation curve necessary for SLF has been determined and a Log Potentiometer matching this is on order.

It is estimated that such a control will yield a SLF $\pm$ 30 kc. The volume of this potentiometer is only about .08 cubic inches.

c. The diode samples on hand did not track satisfactorily in multiple section tuners. However, by inspection of frequency-voltage curves, it was noted that the extremely voltage sensitive low end does not track as closely as the high end. By an incremental voltage shift, the low frequencies can be aligned with little effect on the high frequency end. This was accomplished by placing a resistor in the control circuit of one of the diodes to provide the necessary bias correction to bring the low frequency end in. By this means, together with necessary LC trimming, tracking within 10 kc was realized.

d. Temperature coefficient of capacitance measurements were performed over a temperature range of -55 to 85° C and at bias voltages ranging from -.5 to -20 v dc. Stability improved as the biasing voltage increased. For example, at -.5 volts, the frequency deviation at -55° C was approximately 570 kc from a 25°C reference of 24.685 mc. With -20 volts biasing, the deviation was 115 kc from a 45.961 mc reference. Circuits have been made incorporating compensating diodes which significantly improve the temperature stability of the system. This will be reported in detail in the technical memorandum being prepared.

Work is continuing on temperature stabilization, voltage regulation, intermodulation distortion, and the tuning circuitry, and will be reported in supplemental bulletins. It should be realized that a commercial grade diode was sampled in these initial evaluations. Improvements in tracking, Q and stability are expected by the use of new diodes being developed by the Electron Devices Division.

Further information on the circuitry and performance characteristics of the electronic tuning systems may be obtained from [redacted] or Pvt L. Bessen, Electronic Parts and Assemblies Branch, USASRDL, Liberty 2-4000, Ext. 52033.

STAT